

## **TEST EFFECTIVENESS TREND OBSERVATION**

### **Relationship of Design Change and Waived Requirements to Design Maturity**

#### **CONCLUSION:**

For spacecraft hardware with substantial design heritage from a previously successful program, waivers to requirements are approved more frequently to resolve EMC testing issues rather than modification of the hardware design to meet the requirement. Previous spacecraft flight experience provides a valuable basis on which to base engineering judgement; however, each design decision must be justified by a solid technical rationale.

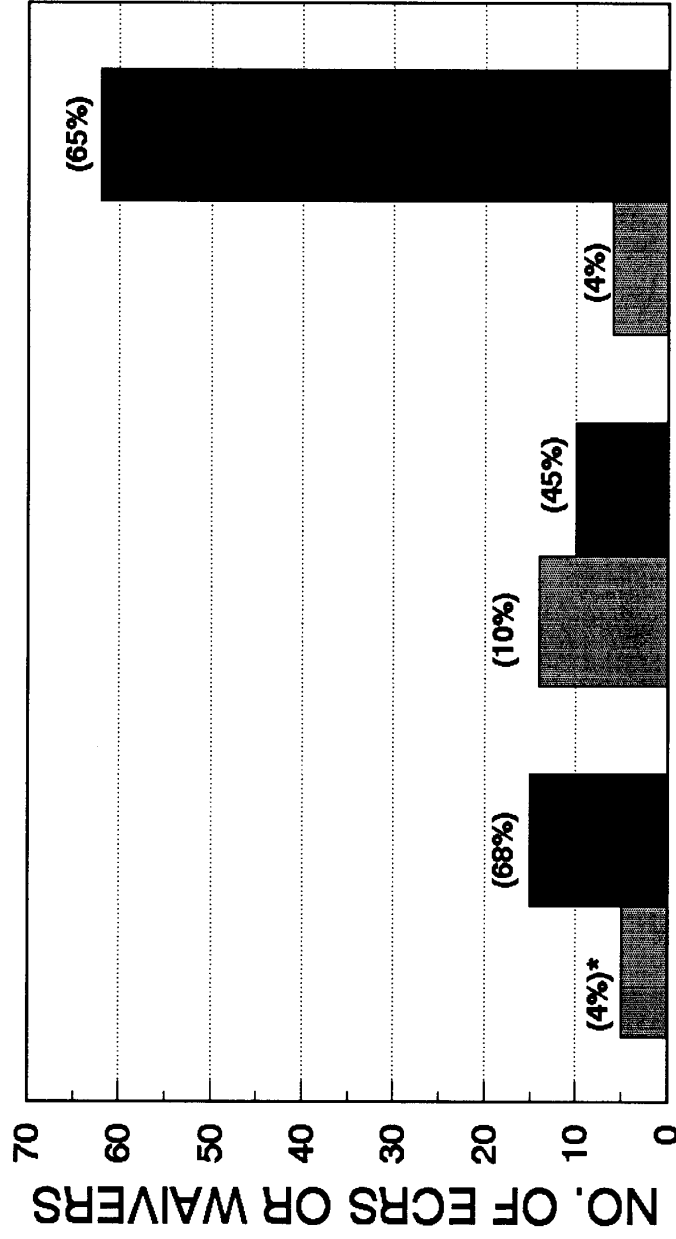
#### **DISCUSSION:**

On the Viking, Voyager, and Galileo projects, 45 percent or more of the waivers resulting from environmental testing occurring during EMC tests, while the number of ECRs was 10 percent or less. An issue arises as to whether there is a relationship between waivers and design changes and flight hardware maturity. Documentation closing PFRs arising during EMC testing provides the basis for addressing this issue. In addition, the Viking, Voyager, and Galileo Projects are projects with flight hardware having varying design maturity. Consequently, the PFR documentation was reviewed to determine whether this data revealed any significant trend.

Both the number of waivers and the number of design changes, based on processed ECRs, were determined from the closure documentation for PFRs written during EMC testing. The results for the Viking, Voyager, and Galileo Projects are provided in Figure 1. The total number of ECRs and waivers resulting during EMC testing is shown, as well as, the percentages that these numbers represent of the total number received during environmental testing. The Viking and the Galileo data are strikingly similar in that the percentages of ECRs and Waivers and the total number of ECRs are nearly identical. Voyager, on the other hand, had about 2.5 times as many ECRs as a percentage and a range of 2.3 to 2.8 times as many as an absolute number. Galileo had a significantly larger number of waivers which is discussed below.

The main difference between the Voyager and the Viking and Galileo programs is that the Voyager was a new design; while the Viking Orbiter and Galileo orbiter were backed by substantial experience with similar designs. The Viking Orbiter incorporated hardware experience from Mariner 71 and the Galileo Orbiter incorporated Voyager hardware experience. Both the Mariner 71 and the Voyager missions were highly successful. The success of these missions provided a mature design for the Viking and Galileo hardware and provided additional confidence in the hardware.

# **ECRS & WAIVERS RESULTING FROM VIKING, VOYAGER & GALILEO EMC TESTING**



PROJECTS	VIKING	VOYAGER	GALILEO
ECRS	5	14	6
WAIVERS	15	10	62

\* ( ) PERCENT OF TOTAL ENVIRONMENTAL TEST ECRS OR WAIVERS

Thus, these results indicate that for mature designs from successful programs, waivers to EMC requirements are approved more frequently than ECRs, which request a design modification to meet the requirement. However, the waiver approval process must also include a thorough technical understanding of the residual risk that is involved in the waiver of the requirement. This understanding for most flight projects is gained through a formal risk assessment.

The large number of ECRs on the Voyager program was related not only to the new design of hardware but also to the fact that design changes were necessary to accommodate the more hostile radiation environment at Jupiter defined by the Pioneer space missions late in the Voyager design process. In addition, Galileo had over four times as many waivers as Viking and over 6 times as many as Voyager. This difference was due in large part to a decision to stay with a conservative specification for the standard digital signal interfaces rather than initiate an ECR to revise it. As a result, the same circuit on each assembly failed the test and required a PFR and waiver.